**United International University**

Department of Computer Science and Engineering

Bachelor of Science in Computer and Engineering

CSE 2217: Data Structure and Algorithms II

Mid Examination: Spring 2026, Duration: 1 Hour 30 Minutes, Total Marks: 30

Answer all questions. Marks are indicated on the right side of each question.

*Any examinee found adopting unfair means will be expelled from the trimester/program as per UIU disciplinary rules.*

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1. a) Prove that $2n^2 + 3n + 5 = O(n^2)$ using the definition of Big-O notation. [2]

b) A sorting algorithm has a time complexity of $\theta(n^2)$.

i. Comment on its best-case and worst-case time complexity. [1]

ii. Explain how the time complexity in both best and worst cases will change if the input size is doubled. [1]

2. a) An alternate version of the Quick Sort algorithm, called the Quicker Sort, uses a Median function which always picks the median element as pivot in O(log n) time. The Partition function of this algorithm takes O(log n) time, and the array is recursively split into two equal halves to complete the sorting.

i. Write a recurrence relation for the Quicker Sort algorithm. [1]

ii. Solve this recurrence relation using any method of your choice. [2]

iii. What is the worst-case time complexity for the Quicksort algorithm? Why does the Quicksort algorithm achieve worst-case time complexity when it is applied on a sorted array? [2]

b) i. Design a Divide and Conquer algorithm to find the sum of all the elements divisible by 3 of an array. You must write the steps of your algorithm, and identify the Divide, Conquer, and Combine parts of your algorithm. [2]

ii. Find the Cross Sum for the subarray = [4 -6 3 -1 -5 6 -7 3]. What is the time complexity of finding the cross sum for an array of size N? (Note: You do not need to calculate the maximum subarray sum; only calculate the cross sum for the given subarray) [2]

iii. What is the time complexity of finding the maximum sum subarray of an array that has no negative numbers? Why? [1]

3. a) A traveler has a backpack that can carry a maximum of 50 kg. There are four items available, each with a certain weight and value.

| Item | Weight (kg) | Value (BDT) |
|---|---|---|
| A | 10 | 60 |
| B | 20 | 100 |
| C | 30 | 120 |
| D | 15 | 75 |

The traveler is allowed to take fractions of items if necessary. Find the maximum achievable total value and determine which items should be selected by performing a step-by-step simulation. [4]

b) “Data encoded using Huffman coding is uniquely decodable.”- Is the statement true? Justify your answer. [2]

c) Imagine that UIU has organized a picnic, featuring several games. A student wants to participate in as many games as possible, so he decides to follow a strategy: he will join the shortest-duration games first to maximize his time for other games. Is this strategy optimal? Explain your reasoning by providing an example. [2]

4. a) A delivery robot needs to travel across a fixed route that requires exactly 8 units of energy to complete.
The robot cannot recharge partially—it must use pre-manufactured energy packs. Each energy pack provides a fixed amount of energy. The available types of energy packs provide:

- 1 unit
- 3 units
- 5 units
- 6 units

The robot can use any number of packs of each type.
However, due to weight constraints, the robot should carry as few energy packs as possible.
i. Using Dynamic Programming, determine the minimum number of energy packs required for the robot to complete the journey exactly using 8 units of energy. [4]
ii. Also, show the combination of energy packs used to achieve this minimum. You must clearly demonstrate the step-by-step process, including how the solution is built (e.g., table formation or state transitions). [2]

b) Why is the overlapping subproblem property important for applying Dynamic Programming? [2]